Organization Research Program

INFORMATION REQUIREMENTS FOR RESEARCH & DEVELOPMENT

Statement of Research Plan

September, 1963 #31-63

M.I.T. [illegible]

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Analysis of the effectiveness of the national research and development effort directs attention to the process of information transfer--the generation, storage, summarization, and retrieval of the ideas and data of science and technology. The report of the President's Science Advisory Committee on <u>Science, Government, and Information</u> (1963) has stressed the essential point that "the information process is an integral part of research and development. Research and development cannot be envisaged without communication of the results of research and development; morever, such communication involves in an intimate way all segments of the technical community, not only the documentalists.

"We place special stress upon what seems an obvious point because, in the early days of science, the problem of communication could be managed casually. Each individual scientist could work out his own private communication system, suitable to his own needs, and, since the requirements were relatively small, the whole matter could be treated rather incidentally. But with the growth of science a casual attitude toward communication can lead only to insufficient communication. Scientists individually, technical societies, agencies supporting research and development, will have to recognize that adequate communication no longer comes free. Communication cannot be viewed merely as librarians' work, that is, as not really part of science. An appreciable and increasing fraction of science's resources, including deeply motivated technical men as well as money, will inevitably have to go into handling the information that science creates" (p.14).

The overriding questions of the design and scale of information systems can only be solved, however, with better knowledge of the information needs of the users. Surveys of time allocation by scientists (Ackoff and Halbert, 1958) and engineers indicate that over 50 per cent of their working time is devoted to communication functions: receiving, preparing and disseminating information. Information handling serves two principal functions: (1) management; i.e. direction, coordination, reporting, and control, and (2) technical problem solution. We are concerned primarily with the second function.

Previous studies have asked researchers, by interview or questionnaire, what knowledge they needed, what sources they made use of, and what function the information served (Brownson, 1960). These studies have been analyzed and compared in a monograph prepared for the National Science Foundation by the Bureau of Applied Social Research of Columbia University (1960). Other work has dealt with the reading behavior of scientists (Hensley, 1962; Hoyt, 1962; Scott, 1962), and the flow and use of information and ideas in university and industrial research (Bureau, 1958, Rubenstein and Avery, 1959). It should be noted that the judgment of the researcher has been the only criterion of the value of the information. In this study, it is proposed that an objective, external evaluation of solutions be related to information handling and utilization.

COMPARISON OF INFORMATION SOURCES

In order to discover instances where information should have been available to a research group, but was not, instances must be sought out in which the same problem is attempted by two or more research groups. In this way, a comparison can be made between the information sources leading to specific solutions. Upon completion of the problem, an investigation will be made to determine whether these sources were mutually available and if not, what the impediments may have been.

Research on research is intrinsically difficult because the outcomes of different projects cannot be directly compared. The opportunity to obtain replication of attempted solutions to the same research problem is rare. Seldom do two or more groups undertake to solve the same problem at the same time (same state of knowledge). This is inevitable because any research study attempts to perform a unique task. If the problem has previously been solved it is, by definition, not a research problem.

Comparative studies of research success might be possible in a university graduate department if a number of Ph.D. candidates were assigned the same thesis problem. Although this occurs in architectural design competitions, there are no instances in scientific research. Replication of problem solving is easily achieved in laboratory experimentation, but in such experiments the problems have been trivial and have not approximated the complexity or requirements of even the simplest research.

Real-life opportunities for the comparative study of differing approaches to the same problem have never been exploited. In addition to whatever adventitious instances of simultaneous parallel research activity may exist, there are three well-defined situations satisfying this criterion:

1. Government contract proposal competitions. Procurement agencies in the government usually distribute a Request for Proposal to which from 6 to 20 firms respond with proposed solutions to the stated problem.

2. Government parallel contracts. In a limited number of instances a government procurement agency will award identical contracts simultaneously to two or more firms. Usually these contracts are for feasibility studies or preliminary designs, but this phase of the R&D process is one that contains many of the difficult and theoretical components of the total effort.

3. Program definition contracts. A new procedure in government contracting is to award to two or more firms a short-term contract calling for preliminary study and design of large complex systems. The resulting reports are evaluated for their technological validity. Such contracts, of which there are only a very few at present, will provide an excellent opportunity for comparative study of research performance.

Preliminary exploration of the possibilities in these parallel effort situations has been carried out only in the first, or proposal competition, situation. The results (Allen and Marquis, 1963a, 1963b) have been sufficiently interesting to justify extension of the work in similar situations.

PROPOSED RESEARCH PLAN

The second of the possible situations-government parallel contracts--has been selected for the next phase of the study. Program definition contracts represent a resource for the near future.

Each of the major government procurement agencies (DOD, NASA, etc.) will be visited in order to identify the past, present, and future parallel contracts. Information will then be obtained both from the government agencies and from the laboratories performing the research. Preliminary investigation has indicated a willingness on the part of government agencies and industrial firms to cooperate in a project of this sort.

In each participating laboratory, the project director and his principal research associates will be given a detailed structured interview at the beginning and at the completion of the contract work. They will be asked to maintain a daily record of the man-hours spent in securing technical information and of the sources and functions of such information. Because attempts to secure complete logs or diaries from busy researchers have not been entirely successful in the past, a special form has been designed for this purpose. This form minimizes the amount of time required for completion by using codes to identify the particular methods of acquisition and the functions for which the information was sought. In classifying functions, we will utilize categories based upon those developed by Dr. Herbert Menzel (1958) of Columbia University. Data will thus be obtained on the various sources of ideas: previous related experience, memory, journals, handbooks, texts, company reports, government publications, technical experts within the company, outside consultants, informal contacts, etc.

In order to follow the course of development of the major solutions during each research project, the project director will dictate on a tape recording machine the principal problems encountered and the means by which a solution was

sought. Key researchers will be asked to estimate weekly the probability that each of several alternative solution possibilities will become the final solution. This will be accomplished through the use of Solution Development Records which require the researcher merely to encircle the appropriate probability estimates.

Upon completion of each project, the competing laboratories will be revisited and detailed interviews, based upon data already collected, will be conducted. Since both solutions and information sources will be known at this time, interviews will be directed to determining which sources contributed to differing solutions and whether these sources were mutually available to both research teams. In cases where the source was mutually available, more detailed information will be obtained regarding factors which may have interfered with proper use of the information source. The tape record of problems encountered and the Solution Development Records will be used to isolate major difficulties and sudden changes in the design. The critical incident technique can then be used to ask researchers exactly what happened at a certain point in the project, whether there was a failure or difficulty in obtaining information, and how information leading to major changes was obtained.

SCHEDULE

On the basis of preliminary experience it is estimated that it will be possible to study about 15 firms at the same time. Since the average duration of the projects is six months, we hope to complete studies of 30 firms on 12 parallel contracts during the year.

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Work Experience

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1957-59 The Boeing Company, Seattle, Washington (BOMARC flight test program, design of system and subsystem tests and analysis of flight test data. Participated in the conduct of SAGE controlled BOMARC flight tests at Atlantic Missile Range (Cape Canaveral).

1959-63 The Boeing Company, Boston Engineering Office (Preliminary system design--command and control of ballistic systems)

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Publications

Problem Solving by Research Groups: A Study of Factors Influencing Technical Quality in the Preparation of Proposals for Government Contract. S.M. Thesis, M.I.T. School of Industrial Management, 1963.

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1953-57	President, American Board of Examiners in Professional Pyschology
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Selected Publications

Conditioning and Learning (with E. R. Hilgard). New York: Appleton-Century-Crofts, Inc., 1940.

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